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(54) **APPARATUS AND METHOD FOR REMOTELY TESTING MULTIPLE COMMUNICATION CHANNEL INPUTS TO A VEHICLE COMPUTER**

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G06F 19/00 (2006.01)

(52) **U.S. Cl.** **701/33**; 701/29; 455/41.2

(58) **Field of Classification Search** 701/33, 701/29, 35, 136; 455/41.2, 425, 466
See application file for complete search history.

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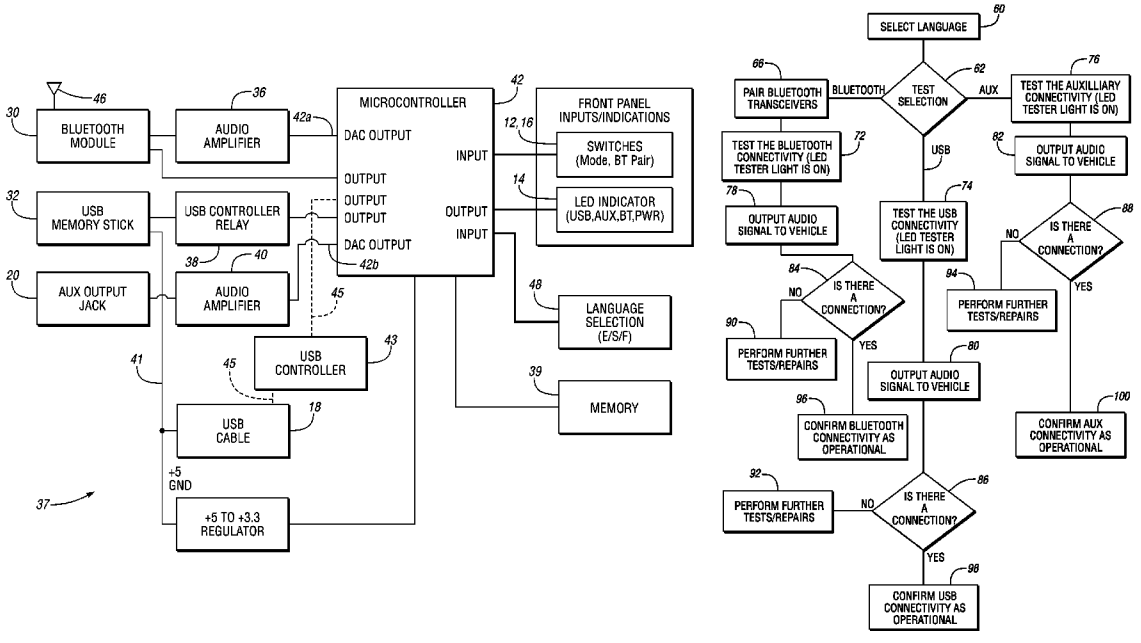
(57) **ABSTRACT**

An embodiment of the present invention includes an apparatus for remotely testing a plurality of communication channel inputs to an automobile computer. The apparatus may include a microprocessor electrically connected to a persistent memory. The memory may have stored therein communication channel test messages corresponding to each of two or more communication channel inputs to an automobile computer. At least one of the communication channels is a wireless communication channel. The microprocessor may be configured to output a test message over a selected communication channel to the automobile computer.

20 Claims, 7 Drawing Sheets



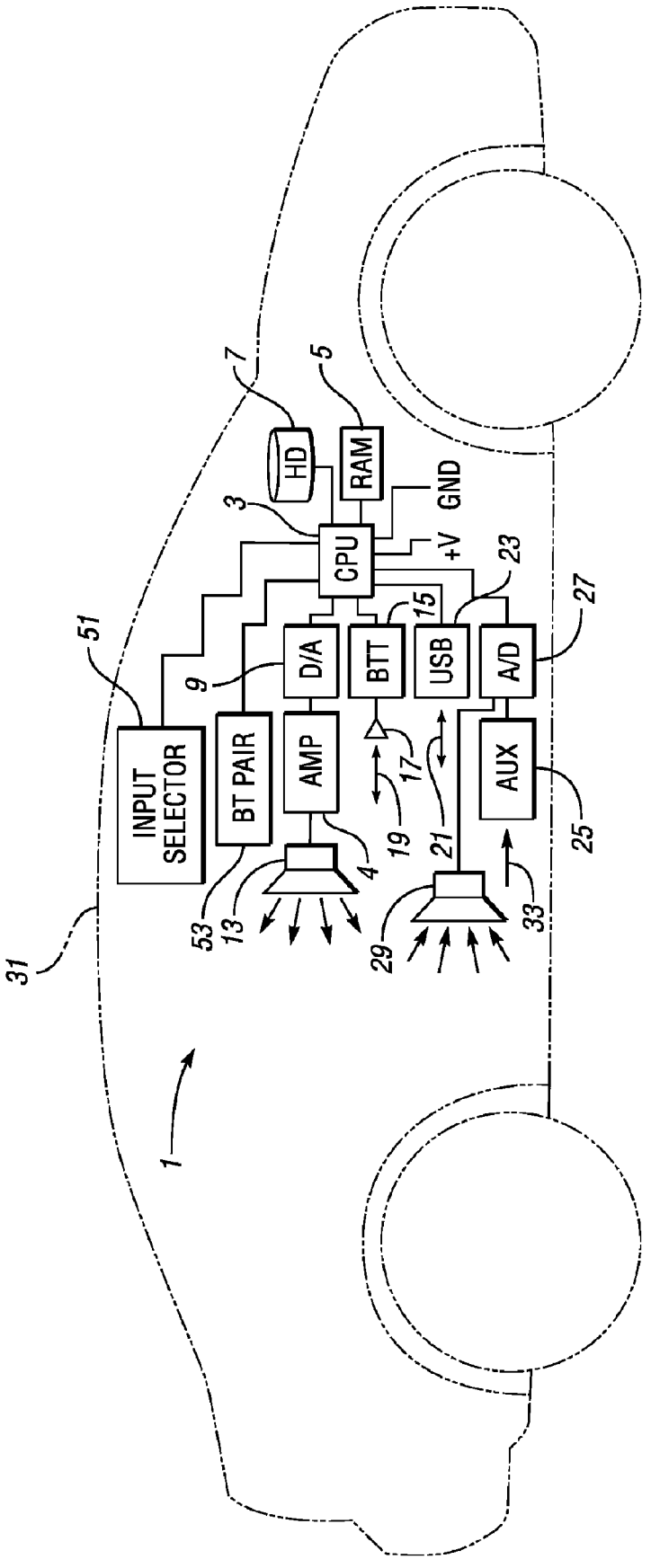

HD
RAM
GND
+V
CPU
D/A
BTT
USB
A/D
INPUT SELECTOR
BT PAIR
AMP
AUX
1
3
4
5
7
9
13
15
17
19
21
23
25
27
29
31
33
51
53

Fig. 1

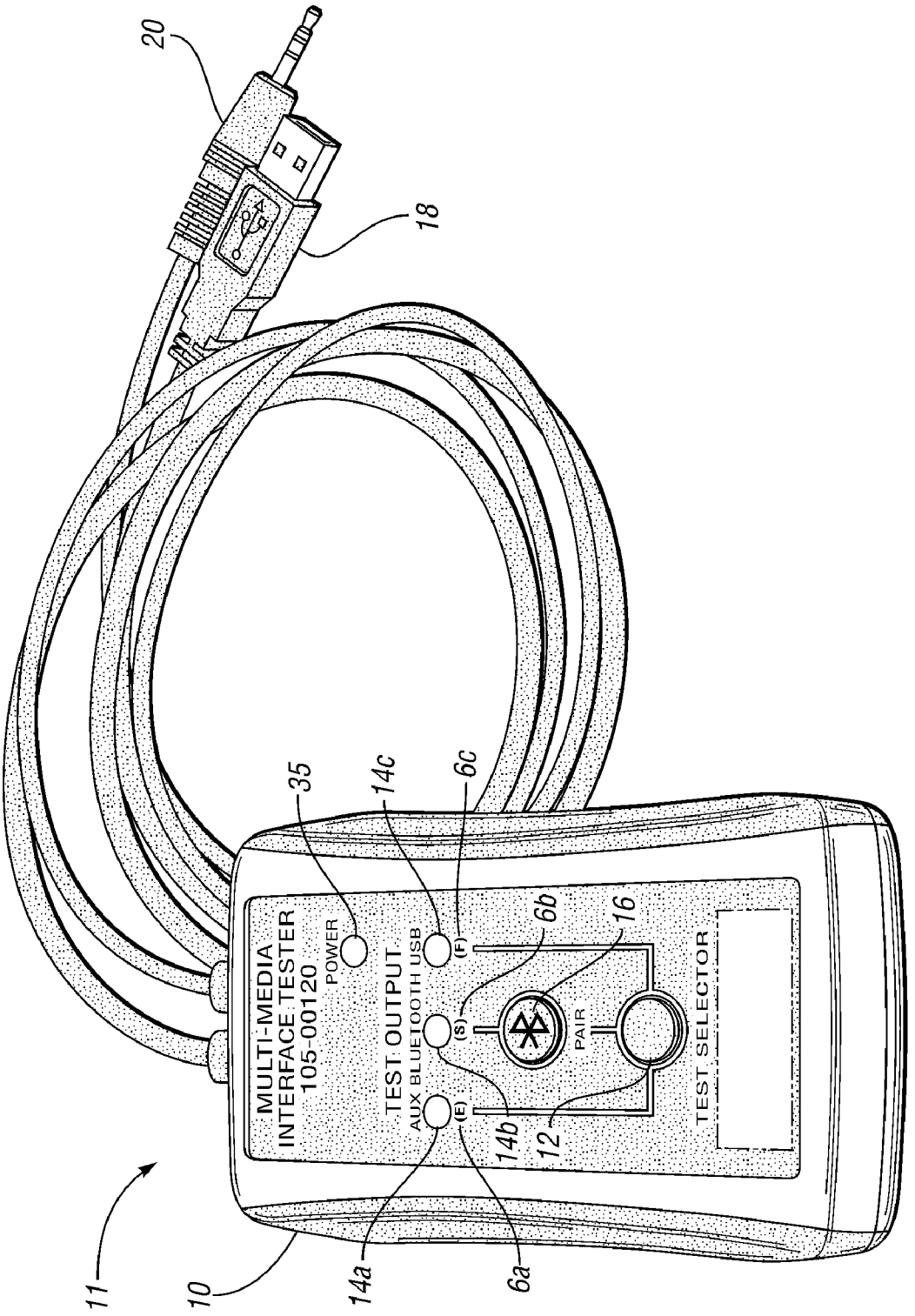

20
18
35
14c
6c
6b
16
MULTI-MEDIA
INTERFACE TESTER
105-00120
POWER
TEST OUTPUT
AUX BLUETOOTH USB
(F)
(S)
(E)
PAIR
TEST SELECTOR
14b
12
14a
6a
10
11

Fig. 2

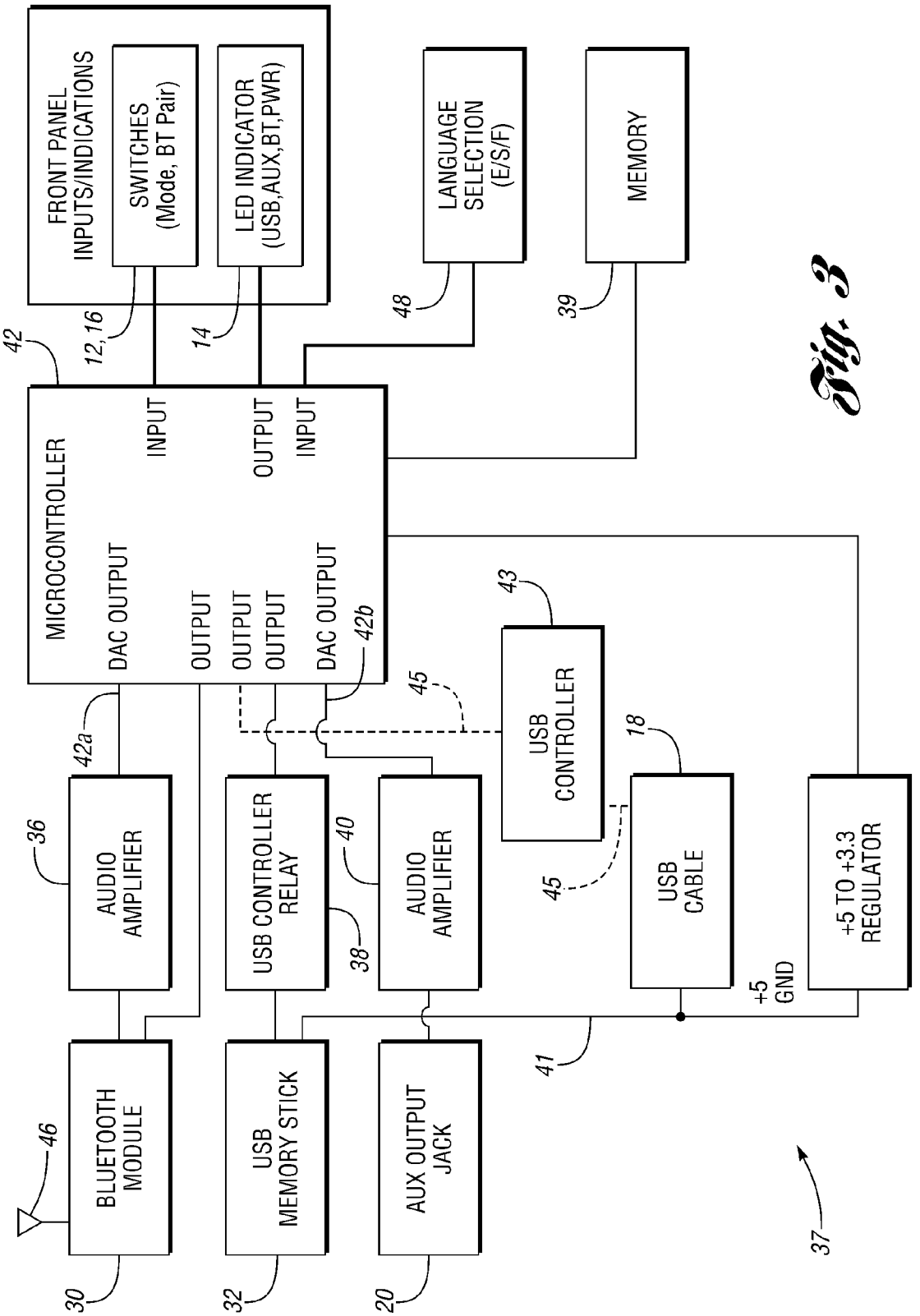

FRONT PANEL INPUTS/INDICATIONS
SWITCHES (Mode, BT Pair)
LED INDICATOR (USB,AUX,BT,PWR)
LANGUAGE SELECTION (E/S/F)
MEMORY
12, 16
14
48
39
42
MICROCONTROLLER
INPUT
OUTPUT
INPUT
DAC OUTPUT
OUTPUT
OUTPUT
OUTPUT
DAC OUTPUT
42b
42a
43
45
USB CONTROLLER
18
36
AUDIO AMPLIFIER
USB CONTROLLER RELAY
40
38
AUDIO AMPLIFIER
45
USB CABLE
+5 TO +3.3 REGULATOR
+5
GND
41
46
BLUETOOTH MODULE
USB MEMORY STICK
AUX OUTPUT JACK
30
32
20
37

Fig. 3

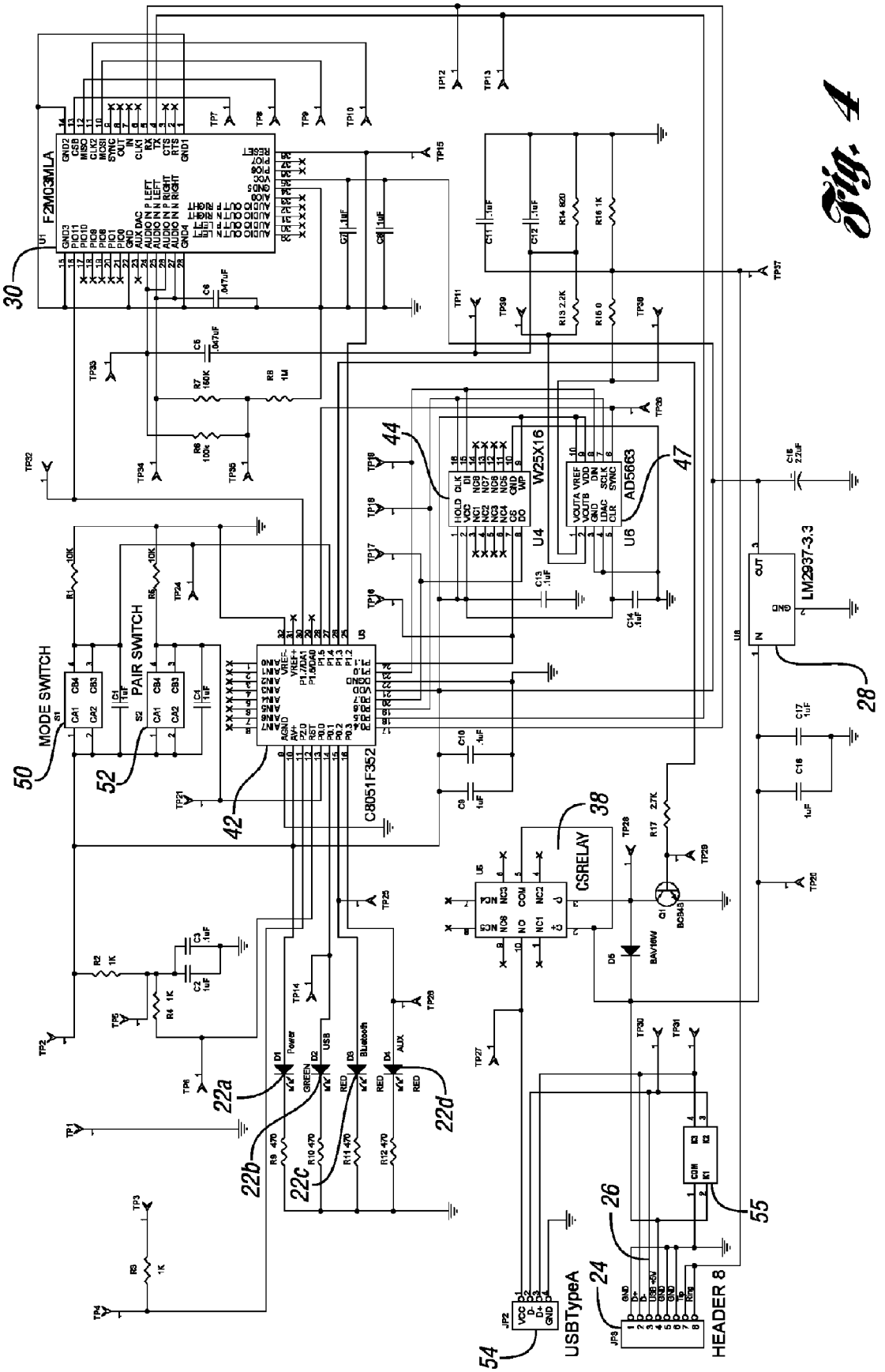

F2M03MLA
C8051F352
W25X16
AD5663
LM2937-3.3
CSRELAY
MODE SWITCH
PAIR SWITCH
USBTypeA
HEADER 8
Power
USB
Bluetooth
AUX
30
42
44
47
50
52
54
55
22a
22b
22c
22d
24
26
28
38

Fig. 4

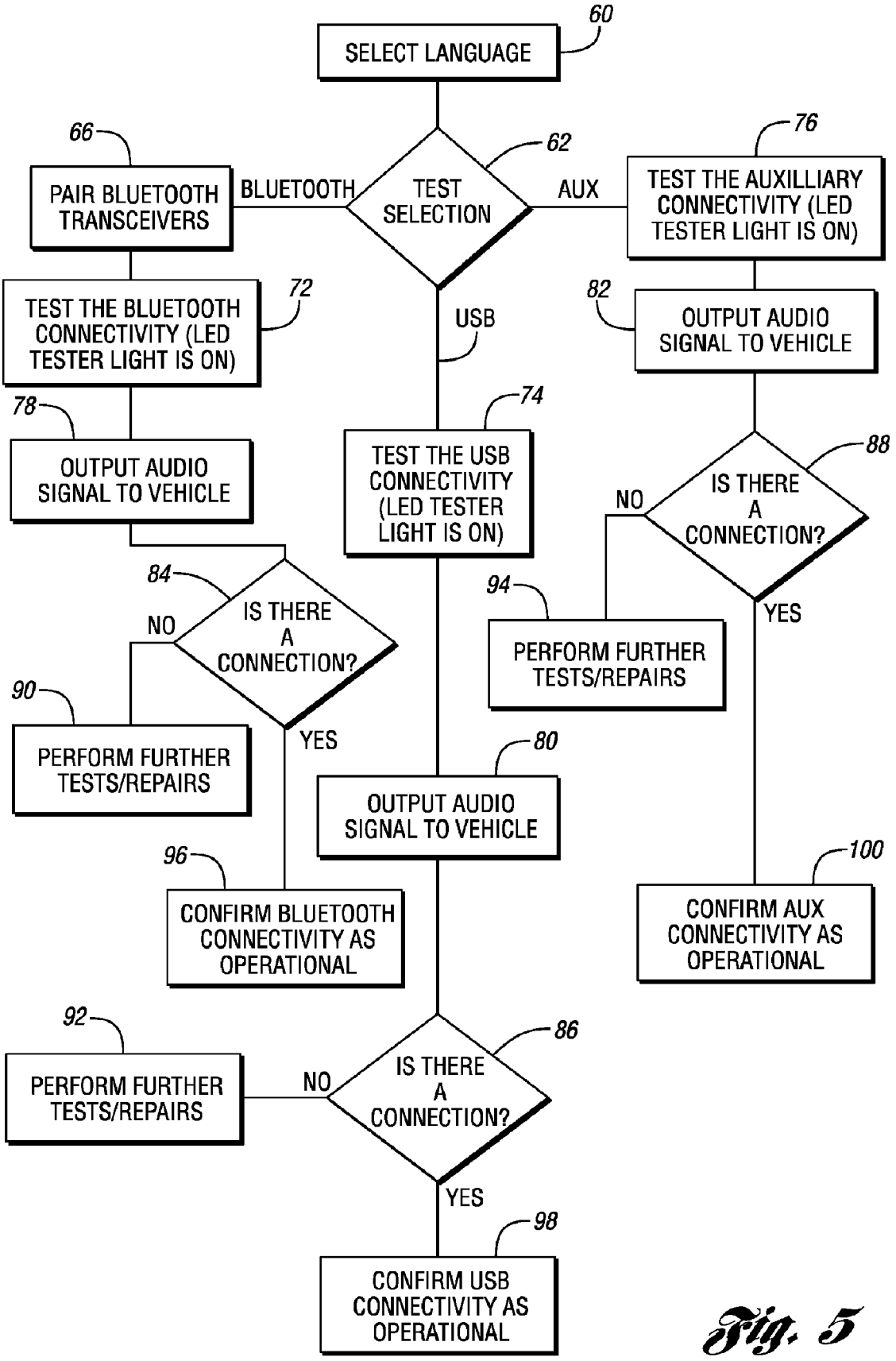

SELECT LANGUAGE
60
TEST SELECTION
62
BLUETOOTH
AUX
USB
PAIR BLUETOOTH TRANSCEIVERS
66
TEST THE AUXILLIARY CONNECTIVITY (LED TESTER LIGHT IS ON)
76
TEST THE BLUETOOTH CONNECTIVITY (LED TESTER LIGHT IS ON)
72
OUTPUT AUDIO SIGNAL TO VEHICLE
82
OUTPUT AUDIO SIGNAL TO VEHICLE
78
TEST THE USB CONNECTIVITY (LED TESTER LIGHT IS ON)
74
IS THERE A CONNECTION?
88
NO
YES
IS THERE A CONNECTION?
84
NO
YES
PERFORM FURTHER TESTS/REPAIRS
94
PERFORM FURTHER TESTS/REPAIRS
90
OUTPUT AUDIO SIGNAL TO VEHICLE
80
CONFIRM BLUETOOTH CONNECTIVITY AS OPERATIONAL
96
CONFIRM AUX CONNECTIVITY AS OPERATIONAL
100
PERFORM FURTHER TESTS/REPAIRS
92
IS THERE A CONNECTION?
86
NO
YES
CONFIRM USB CONNECTIVITY AS OPERATIONAL
98

Fig. 5

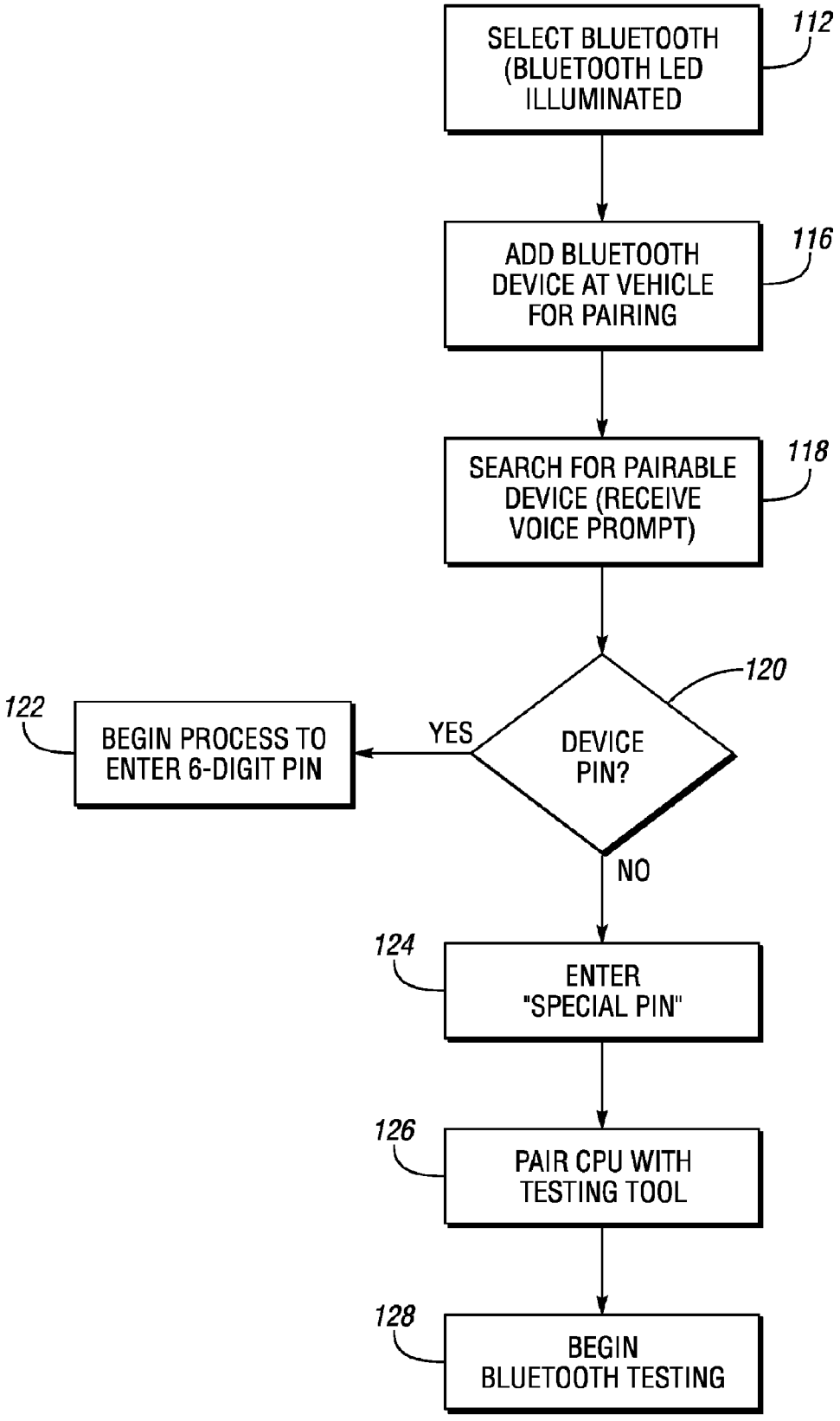

SELECT BLUETOOTH (BLUETOOTH LED ILLUMINATED
112
ADD BLUETOOTH DEVICE AT VEHICLE FOR PAIRING
116
SEARCH FOR PAIRABLE DEVICE (RECEIVE VOICE PROMPT)
118
DEVICE PIN?
120
YES
122
BEGIN PROCESS TO ENTER 6-DIGIT PIN
NO
124
ENTER "SPECIAL PIN"
126
PAIR CPU WITH TESTING TOOL
128
BEGIN BLUETOOTH TESTING

Fig. 6A

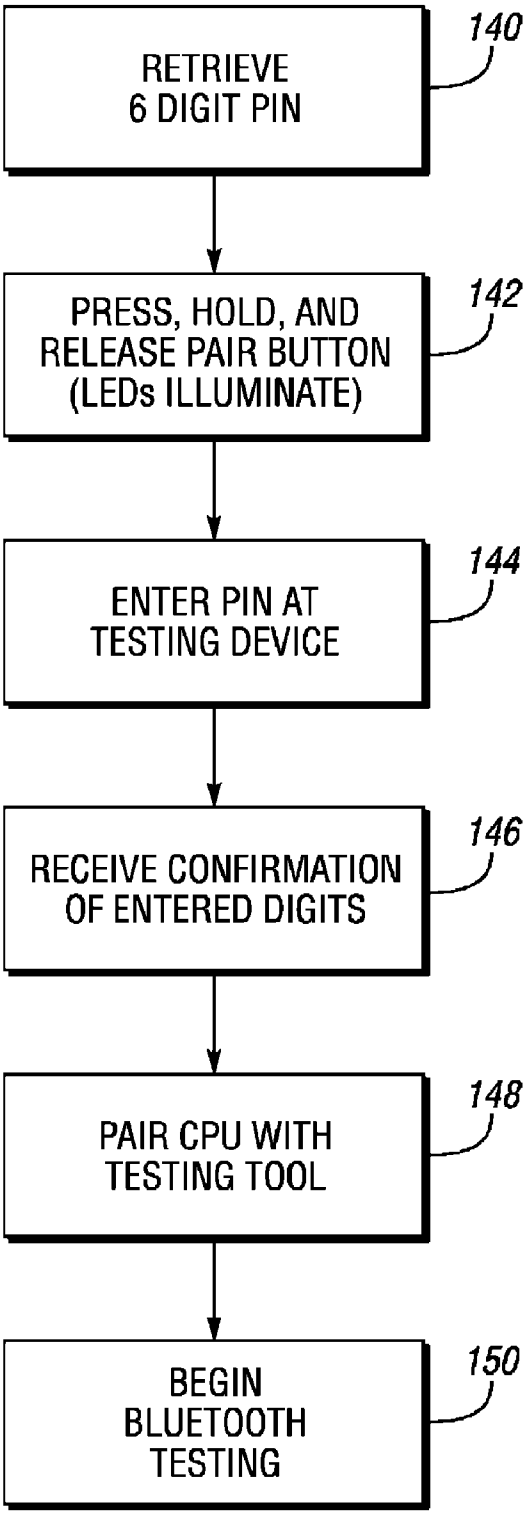

RETRIEVE 6 DIGIT PIN
140
PRESS, HOLD, AND RELEASE PAIR BUTTON (LEDs ILLUMINATE)
142
ENTER PIN AT TESTING DEVICE
144
RECEIVE CONFIRMATION OF ENTERED DIGITS
146
PAIR CPU WITH TESTING TOOL
148
BEGIN BLUETOOTH TESTING
150

Fig. 6B

APPARATUS AND METHOD FOR REMOTELY TESTING MULTIPLE COMMUNICATION CHANNEL INPUTS TO A VEHICLE COMPUTER

BACKGROUND OF THE INVENTION

1. Field of the Invention

Embodiments of the present invention relate to an apparatus and method for remotely testing multiple communication channel inputs to a vehicle computer.

2. Background Art

U.S. Pat. No. 4,694,408 (directed to an apparatus for testing auto electronics systems) and U.S. Pat. No. 4,831,560 (directed to a method for testing auto electronics systems) disclose an interactive system and method for testing vehicle electronics systems in which various vehicle subsystems are exercised under the control of a tester unit while the performance of associated subsystems are monitored to detect and isolate malfunctions. The tester includes interchangeable program cartridges that can be easily inserted to adapt the unit for a variety of different vehicles and test procedures, and also optional interchangeable input/output cartridges for test procedures in which additional access to or from the tester or peripheral devices is necessary. The test unit accesses the vehicle's electronics data bus by means of an assembly line diagnostic link, the access being accomplished via a multiplexer that makes it possible to locate faults on the data bus itself. The tester greatly reduces the time and effort necessary to analyze malfunctions in the field, and is considerably more comprehensive than prior test equipment.

U.S. Pat. No. 5,541,840 directed to a handheld automotive diagnostic service tool discloses a system and method for diagnosing and isolating problems and for monitoring operating conditions on an automobile. The system includes a hand held unit and a master station which can operate alone or in unison to accomplish functions such as logging and displaying data on a real-time basis, logging data remotely and displaying the data at a later time, diagnosing fault conditions, monitoring operating parameters, reprogramming on-board vehicle controllers, displaying service manual and service bulletin pages and ordering parts on-line.

U.S. Pat. No. 6,603,394 B2 directed to a multi-protocol wireless communication module discloses a wireless communication module that communicates with a remote station and a plurality of motor vehicle control units that implement at least two different communication protocols within a single motor vehicle. The wireless communication module includes an RF interface, a processor and a selectable multiple protocol interface. The processor communicates with the RF interface and thereby communicates with the remote station. The processor executes diagnostic routines and thereby provides commands to one of the plurality of motor vehicle control units. The selectable multiple protocol interface is coupled between the plurality of motor vehicle control units and the processor. The selectable multiple protocol interface converts processor commands into a format that is readable by the selected motor vehicle control unit and converts received diagnostic information into a format that is readable by the processor. If desired, both the selectable multiple protocol interface and the processor functionality can be incorporated within the field programmable gate array.

SUMMARY OF THE INVENTION

An embodiment of the present invention includes an apparatus for remotely testing a plurality of communication channel inputs to an automobile computer. The apparatus may include a microprocessor electrically connected to a persistent memory. The memory may have stored therein communication channel test messages corresponding to each of two or more communication channel inputs to an automobile computer. At least one of the communication channels is a wireless communication channel. The microprocessor may be configured to output a test message over a selected communication channel to the automobile computer.

An embodiment may include a wireless transceiver in communication with the microprocessor for wirelessly communicating at least one of the test messages to a wireless communication input to the automobile computer.

An embodiment may include one or more switches connected to the microprocessor which, upon operation, cause the microprocessor to pair the wireless transceiver with the wireless communication input to the automobile computer, select one of the two or more communication channel inputs and corresponding test messages for testing, and output the corresponding test message over the selected communication channel input.

The wireless communication channel may be a BLUETOOTH communication channel. The apparatus may include one or more output indicators to identify which of the two or more communication channels has been selected for testing. The output indicator may be a light emitting diode.

The communication channel test messages may be stored in two or more different languages, and operation of the switch(es) may cause the microprocessor to select the language of the test message for output over the selected communication channel.

The two or more communication channels may include a universal serial bus. A voltage differential on the universal serial bus may provide power to the microprocessor.

The persistent memory may be flash memory.

The apparatus may include a digital-to-analog converter for converting digitally-encoded test messages into analog audio signals.

An embodiment of the present invention includes a method for remotely testing the operability of two or more communication channel inputs to a vehicle computer. At a test tool remote from the vehicle computer, the method may include receiving input selecting one of two or more communication channel inputs to the vehicle computer, at least one of which is a wireless communication channel, pairing a wireless transceiver in the test tool with a wireless transceiver electrically connected to the vehicle computer, and outputting over the selected communication channel a test message unique to that communication channel.

At a vehicle computer, the method may include receiving input selecting one of one of two or more communication channel inputs to the vehicle computer, (2) receiving input for pairing a wireless transceiver in communication with the vehicle computer with a wireless transceiver in the test tool, and (3) if the test message is received at the vehicle computer over the selected communication channel, outputting the message for playback over the vehicle audio system.

The method may also include illuminating at the test tool an indicator identifying which communication channel has been selected for testing.

The method may include selecting a test message language from two or more languages at the test tool, and outputting the test message over the selected communication channel in the selected language. An indicator may be illuminated at the test tool identifying which test message language has been selected.

The method may include receiving at the test tool input defining a multiple digit PIN number for pairing the wireless transceiver with the wireless transceiver electrically connected to the vehicle computer.

The method may include establishing a universal serial bus or analog communication connection between the test tool and the vehicle computer.

The method may include converting a test message in a digital format to an analog format at the test tool for communication to a vehicle entertainment system over an analog communication channel.

These and other aspects of the present invention will be better understood in view of the attached drawings and following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood with reference to the following description, taken in connection with the accompanying drawings, of which:

FIG. **1** is an exemplary block topology for a vehicle computing and communication system.

FIG. **2** is exemplary embodiment of a test tool for testing a plurality of communication channels at a vehicle computer.

FIG. **3** is an exemplary embodiment of the circuitry implemented in the multimedia testing tool.

FIG. **4** is one embodiment of the PC board layout implemented within the multimedia testing tool.

FIG. **5** is an exemplary flow diagram illustrating one embodiment of the operation of the multimedia testing tool.

FIG. **6**A is an exemplary flow diagram illustrating one embodiment of a BLUETOOTH pairing process of the multimedia testing tool to the vehicle computer.

FIG. **6**B is an exemplary flow diagram illustrating another embodiment of a BLUETOOTH pairing process of the multimedia testing to the vehicle computer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

FIG. **1** illustrates an example block topology for a computing and communication system **1** (CCS) for a vehicle **31**. Central processing unit (CPU) **3** may include a digital data processor or microprocessor, and is powered with positive direct current voltage +V (e.g. 5 volts DC). The CPU may be in operable communication with volatile or random access memory (RAM) **5**. CPU **3** may also have access to database or hard drive **7** for persistent information storage and retrieval. Alternatively or in addition, CPU **3** may interface with flash memory, such as a flash drive or smart card (not shown). CPU **3** may have a digital output to digital-to-analog converter **9** for converting digital signals into analog signals such as audio or video signals. Those signals may be amplified for playback at speaker(s) **13** or a video display (not shown), as is well known in the art. Alternatively, a digital signal processor may process digital signals for playback at speaker(s) **13** or a visual display (not shown). Computing and communication system **1** may or may not include a global positioning (i.e., navigation) system (GPS) configured for location determination, navigation services, or both.

CPU **3** may have a plurality of input channels. For example, microphone **29** may detect voice and convert that voice to an analog electrical signal. The analog signal may be converted to a digital signal at analog-to-digital converter **27** for input to CPU **3**. Analog signals **33** may also be received at auxiliary input **25**, converted to digital signals at converter **27**, and input to CPU **3**.

CPU **3** may communicate bidirectionally with remote devices via BLUETOOTH transceiver **15** having antenna **17** for communicating radio frequency (RF) signals **19** according to the BLUETOOTH communication specifications and protocol. BLUETOOTH RF communication may be established between CPU **3** and a plurality of remote computing devices including but not limited to cellular telephones, personal media devices, health monitoring devices, laptop or minicomputers, vehicle modules, personal navigation devices and the like.

CPU **3** may also communicate bidirectionally with remote computing devices via universal serial bus (USB) **23**. An input selector **51** may be operated by a vehicle occupant to select among the several available inputs to CPU **3**. For the BLUETOOTH communication channel, a BLUETOOTH pairing mode may be entered by selecting pairing button **53**.

FIG. **2** illustrates one example of a tool **11** for testing one or more of a plurality of communication channels to and from CPU **3**. Tool **11** may include a housing **10** having a plurality of output indicators, e.g., auxiliary **14***a*, BLUETOOTH **14***b*, USB **14***c* and power **35**. In another embodiment, there may be indicators for a plurality of other communication channels. Non-limiting examples include Worldwide Interoperability for Microwave Access (WiMax), Wi-Fi, ZigBee, and wireless USB. The test tool **11** may also test any combination of these plurality of communication channels. Output indicators may include light emitting diodes (LEDs), a liquid crystal display (LCD), or other form of visual output. An indicator may also be provided (not shown) indicating that the tool **11** is or has been paired with another BLUETOOTH device. Tool **11** may also include input buttons or selectors **12** (test selector) and **16** (BLUETOOTH pairing mode). Tool **11** may also include auxiliary output **20**, and USB connection **18** (e.g. High Speed USB 2.0). As explained in greater detail below, tool **11** internally includes a BLUETOOTH transceiver in compliance with the Advanced Audio Distribution Profile (A2DP), specification. Alternatively, the tool **11** may include a BLUETOOTH transceiver compatible with the Hands Free Profile (HFP) or Headset Profile (HSP) specifications or a combination of the various profiles. In one embodiment, the USB interface **18** may provide a voltage differential to testing tool **11**. In another embodiment, the test tool **11** may allow for testing a video output from the CPU **3**. The test tool **11** may test, for example, the audio portion of an MP4. There may be an indicator at the test tool **11** for indicating the testing of the video signal.

LEDs may indicate which communication channel **14***a*, **14***b*, **14***c* is being tested, as described below. A user may operate test selector button **12** to initiate testing of each of the communication channels. A user may operate BLUETOOTH pairing button **16** to pair the BLUETOOTH transceiver located within tool **11** to the BLUETOOTH transceiver **15** located within the vehicle **31**.

A user may operate one or more switches or buttons to select a language for testing one or more of the communication channels. LEDs may also indicate in which language the multiple communication channels are being tested. For example, the LED may indicate that a communication channel **14***a*, **14***b*, **14***c* is being tested in English (E) **6***a*, Spanish (S) **6***b*, or French (F) **6***c*. The communication channels may be tested in other languages. Operation of the language selection functionality of the test tool **11** will be further described below.

Those of skill in the art will appreciate that the external configuration of tool **11** is not limited to the particular configuration illustrated in FIG. **2** and described above. A multitude of different shapes and configurations may be implemented. For example, the test tool may be implemented in software running on a portable computing device, such as a laptop computer, handheld computer or other mobile computing device. The shape and physical configuration of the tool illustrated in FIG. **2** shall not be a limitation of the present invention.

FIG. **3** illustrates a block diagram for example circuitry **37** that may be implemented within tool **11**. Those of skill in the art will appreciate that the particular circuitry utilized to implement embodiments of the present invention is not limited to the particular circuit configuration illustrated in FIG. **3**. For example, the circuitry illustrated in FIG. **3** tests externally originating inputs to CPU **3** inside vehicle **31**. The circuitry of FIG. **3** could be readily configured to test the outputs from CPU **3** communicated through BLUETOOTH transceiver **15** or USB port **23**.

Example circuitry **37** includes a microcontroller **42**. In one embodiment, microcontroller **42** may include a MOTOROLA 8051 8-bit processor (e.g., SILICON LABS C8051F352), a system clock, and memory (e.g. flash, SRAM, XRAM, etc.). Microcontroller **42** may be powered by USB interface **18**. Alternatively, the tool **11** may be powered by internal battery power, solar power, or by one of the vehicle's 12 volt auxiliary power ports (not shown). If a 12 volt DC power supply is used, a voltage regulator may be necessary to supply the microcontroller and other devices with 5 volts DC.

In communication with the microprocessor **42** may be a BLUETOOTH transceiver **30** having an antenna **46**. The transceiver **30** may be an established Advanced Audio Distribution Profile (A2DP) compatible device for streaming of audio between BLUETOOTH devices. The test tool **11** may also be a HFP or HSP compatible device as described above. The transceiver **30** may pair with the vehicle's BLUETOOTH transceiver **15** when testing the BLUETOOTH communication channel. Transceiver control may be accomplished through software encoded on the microcontroller **42**. The transceiver **30** may also be in communication with an audio amplifier **36** for outputting an audio test file stored in persistent memory **39**. The transceiver **30** may be an FCC approved component of the testing device. In one embodiment, the transceiver **30** may pair the testing device **11**, upon pressing the BLUETOOTH pairing button **16**, with the vehicle's BLUETOOTH transceiver **15** during BLUETOOTH connectivity testing. Further details of the operation of the BLUETOOTH testing will be further described below. The pairing may be accomplished through a manufacturer developed automated sequence to allow for successful pairing between the devices, embodiments of which are described below.

A USB flashdrive or memory stick **32** may be housed within the testing device. The USB flashdrive **32** may be used for testing the connectivity of the USB communication channel via connection **41** upon operation of USB controller relay **38**. When the USB test selector **14***c* is depressed, an output signal from microprocessor **42** is generated to activate the USB controller relay **38**. In one embodiment, the controller relay **38** controls the power of the USB flashdrive **32**. For example, the controller relay **38** may keep the power of the flashdrive **32** shut off until testing of the USB communication channel is selected. Alternatively, audio test files stored in persistent storage **39** may be output to USB interface **41** during testing. In one embodiment, test audio files are stored in the flashdrive **32** (and/or memory **39**) as meta files and stored in multiple languages such as English, French, and Spanish. The testing device may or may not provide a language selection capability **48** for the USB connection. In one embodiment the output of the USB connectivity test may include sequential test messages in each language without any selection or change by the user (e.g., service technician) through the language selector **48**.

In an alternative embodiment, language selection can occur at microcontroller **42** through the language selector switch **48** when test messages of different languages are separately addressed within persistent memory **39**. In this embodiment, test signals are output to USB controller **43** and communicated to USB cable **18** via interface **45**.

Microprocessor **42** may also include a digital-to-analog converter (DAC) **42***b* for testing the auxiliary output **20**. In one embodiment, the DAC **42***b* is embedded on the microprocessor **42** and works in communication with the microprocessor's **42** memory **39** to output analog audio files when testing the auxiliary connection.

Microprocessor **42** may also include memory **39** for audio file storage. The audio files stored in the microprocessor **42** memory **39** may be the output that is transmitted when the BLUETOOTH and auxiliary communication channels are tested. The USB flashdrive **32** within the testing device may contain separate memory which stores the audio files used for USB connectivity testing. In one embodiment, the microprocessor **42** stores in persistent memory **39** the audio files for the BLUETOOTH, USB, and auxiliary communication channels, serves as the operation center for the testing device, and contains the circuitry for controlling the testing of all three communication channels. This operation is described in greater detail below.

The microprocessor memory **39** may separately address storage of the audio files in several different languages such as English, French and Spanish. Through the language selector switch **48** in communication with the microprocessor **42**, the memory address for one of these three languages may be selected for playback during testing. In one embodiment, the language selector switch allows language selection for BLUETOOTH, USB and auxiliary channels which are all in communication with the microprocessor **42**. The microprocessor **42** may also contain instructions and circuitry to allow for test switching capabilities between the three communication channels through a test selector button **12** located at the testing device **11** in communication with the microprocessor **42**. The operation of the test selector button **12** will be further described below.

FIG. **4** illustrates an exemplary schematic of the testing tool's **11** PC board layout (PCB). Connector **24** may interface with auxiliary cable interface **20** and USB interface cable **18**. USB connector **24** may include USB power connection (+5v DC) **26** that is regulated by a voltage regulator **28**. In one embodiment, connector **24** is an 8-pin connector.

Connector **24** may be in electrical communication with a surge protector **55** (such as part number SP0505BAHTG manufactured by LITTELFUSE). Interface **54** may connect to the flash/memory stick **32** (FIG. **3**) and transmit audio or video files when in USB mode. Interface **54** may be in electrical communication with a USB controller relay **38** which controls the power to the flash drive (e.g. leaves power off) until the USB channel is tested. Relay **38** is activated by pin **26** of microprocessor **42**.

A mode select switch **50** may transmit an electrical signal when toggling between test modes (e.g., USB, AUX, BLUETOOTH) during protocol testing. A BLUETOOTH pairing switch **52** may transmit an electrical signal for pairing the test tool **11** BLUETOOTH transceiver **30** to the vehicle BLUETOOTH transceiver **15** in order to enable testing of the

BLUETOOTH communication channel. The pairing process will be described in further detail below. During protocol testing, instructions may be sent to microcontroller **42** to light LEDs **22***a* (power), **22***b* (USB), **22***c* (BLUETOOTH) and **22***d* (AUX). For example, when the test tool **11** is powered through USB connection **18**, the LED for power **22***a* may light green. During testing of any protocols, the LEDs **22***b*, **22***c*, **22***d* may light red.

A flash memory chip **44** may store audio files for use during testing. One example of a flash memory chip is part number W25X16VSFIG manufactured by WINDBAND. The use of audio files will be further described in detail below. The flash memory chip **44** may also serve as external persistent memory to the microcontroller **42**.

A Digital-to-Analog Converter (DAC) **47** may be used during testing to convert media from a digital format to an analog format for playback.

A BLUETOOTH module/transceiver **30** may transmit signals for pairing with vehicle transceiver **15**. An example of a BLUETOOOTH module **30** is one manufactured by FREE2MOVE, part number F2M03MLA. An on-board antenna (not shown) may receive and transmit RF signals for transceiver **30** to transceiver **15** pairing/connection.

While there maybe other environments in which the testing device will prove useful, it is contemplated that the testing device will generally be utilized when a vehicle technician is repairing or diagnosing problems with computing and communication system **1** illustrated in FIG. **1**. FIG. **5** discloses a flow diagram illustrating example steps for operating the testing device according to one embodiment. Those of skill in the art will appreciate that the processes illustrated in FIG. **5** may be supplemented or modified to best-fit a particular implementation of the present invention. The present invention, and the operation of the present invention, is not limited to the particular process illustrated in FIG. **5**.

To operate the testing device according to this example, a service technician may power the device by plugging in the USB cable **18** to a powered USB interface port within vehicle **31**. Alternatively, a separate USB or auxiliary power cable (not shown) may be attached to the testing device for power. A service technician may also connect the auxiliary audio jack **20** to an auxiliary interface at vehicle **31**. A service technician is not required to test the communication channels in a specific order. For example, a user may test the BLUETOOTH connection first followed by the auxiliary and USB connections. During the next testing opportunity, the user may first test the USB connection followed by the BLUETOOTH and auxiliary. Accordingly, any communication channel testing order can be implemented. As mentioned above, other communication channels may be tested such as WiMax, WiFi, ZigBee, and wireless USB. The audio portion of an MP4 can also be tested.

Typically, the first step in the testing process is to select the language for the testing, as indicated at block **60**. This is because all tests are typically performed by the same technician in the same language, regardless of the communicating channel being tested. In one embodiment, English, French or Spanish may be selected as the output language. In the USB mode, all languages may be outputted sequentially.

To change languages according to one embodiment, the test selector button **12** may be pressed and held for a predetermined amount of time (e.g., 3 seconds) until LEDs **6***a*-**6***c* blink. While holding test selector button **12** pressed, the pair button **16** may be pressed to select the desired language, until the LED **6***a*, **6***b*, or **6***c* for the desired language has been illuminated.

Next, the technician may select the particular communication channel to test, as indicated at block **62**. In this example, there are three communication channel options: BLUETOOTH, USB and auxiliary. Other communications channels may be tested as described earlier. Communication channel selection may be executed by depressing selector button **12** illustrated in FIG. **2** to sequentially select the desired communication channel for testing. The presently-selected communication channel may be visually identified by LEDs **14** associated with each channel on the face of tool **11**, as illustrated in FIG. **2**. Alternatively, a separate test selection button may be associated with each communication channel.

The vehicle **31** may include an input selector **51** which may be operated to select the desired input to CPU **3**. In this example, the BLUETOOTH input would be selected, channeling signals from BLUETOOTH transceiver **15** to CPU **3** to initiate a pairing with test tool **11**.

To test the BLUETOOTH communication channel, the technician must first pair the BLUETOOTH transceiver **30** within the tool **11** with the BLUETOOTH transceiver **15** in the vehicle **31**, as indicated at block **66**. Pairing mode is entered at tool **11** by depressing the BLUETOOTH pair button **16** illustrated in FIG. **2**. The vehicle **31** may also include a BLUETOOTH pairing button **53** which may be also pressed to complete the pairing operation. FIGS. **6**A and **6**B show two block diagrams representing exemplary embodiments of the pairing operation.

As shown in FIG. **6**A, upon selecting BLUETOOTH testing at test selector **12** as reflected in block **112**, the BLUETOOTH LED **14***b* will illuminate. A menu button (not shown) on the CCS **1** may direct the user to a system settings function for pairing with a BLUETOOTH device as represented in block **116**. A voice prompt outputted from speakers **13** may indicate that a search is being made for pairable devices as represented in block **118**. Once paired, the user may enter a "special PIN" (e.g., "0000") as represented in block **124**. As will be described below, the CCS **1** may be defaulted to requiring a multiple digit (e.g., six-digit) PIN for pairing as indicated in block **120**. Accordingly, a user may be required to select an option a the CCS **1** for entering the "special PIN" as represented in block **124**.

The user may then select the pair button **16** on the testing device **11**. Pairing of the devices as represented in block **126** can be identified by the LED **14***b* blinking several times or for several seconds. Testing of the BLUETOOTH communication channel may then commence as indicated in block **128**.

FIG. **6**B shows an example of the default pairing scenario. The user may be required to retrieve a multiple digit (e.g., six-digit) PIN stored in the CCS **1** as represented in block **140**. The user may enter the six-digit PIN to the testing device **11**. In one example for doing so, the pair button **16** may be held for a predetermined time (e.g., 3 seconds) until LEDs **14***a*-**14***c* illuminate as represented in block **142**. Upon releasing the pair button **16**, the AUX LED **14***a* will remain illuminated. The PIN may be entered by pressing the pair button **16** a number of times equal to each digit of the multiple digit PIN as represented in block **144**. For example, if the first digit is 3 and the second digit is 4, the pair button **16** is pressed 3 and 4 times respectively. The test selector button **12** is pressed after each entered digit. Once selected, LED **14***b* will blink indicating a pair key press has been entered. If the PIN has a "0", then only the test selector button **12** may be pressed.

Confirmation of each entered digit may be received from LED **14***a*-**14***c* from left-to-right as indicated in block **146**. For example, when entering the first digit, LED **14***a* may be

illuminated. Once entered, LED **14***b* may be illuminated for the second digit. LEDs **14***a*-**14***c* will re-illuminate from left-to-right for digits 4-6.

Upon entering all digits of a PIN, LED **14***b* may blink several times or for several seconds. Transceiver **15** will attempt pairing with testing device **11** as indicated in block **148**. Testing of the BLUETOOTH communication channel may commence as indicated in block **150**.

Once the BLUETOOTH transceivers are paired, and the test selector **12** is set to the BLUETOOTH communication channel, the channel communication test is initiated as indicated in block **72**. CCS **1** may need to be configured for BLUETOOTH testing. For example, the user may be required to select "BT Audio" from the CCS **1** interface. A user may test all three communication channels by pairing the devices once. If the BLUETOOTH channel is retested, the user may be required to unplug and re-plug the USB power cable. The device **11** may not remain paired to the vehicle transceiver **15**. Accordingly, the testing device **11** may also be removed from the paired device list of the BLUETOOTH transceiver **15** in communication with the CPU **3**. Upon pairing the devices again, testing may re-commence.

During testing, a test message in the selected language is called from persistent memory **39** and outputted to BLUETOOTH transceiver **30** within the test tool **11** for wireless communication to the BLUETOOTH transceiver **15** within vehicle **31** for playback at speaker **13** within the passenger compartment as indicated at block **78**. An English message may state, for example, "This is a test of the BLUETOOTH communication channel. If you can hear this message, the BLUETOOTH channel is working properly." If this message is heard by the technician, the BLUETOOTH communication channel is determined to be operational, as indicated at block **96**. If the message is not heard, there may be a problem with the BLUETOOTH communication channel and further diagnosis and testing may be required by the technician, as indicated at block **90**.

To test the USB communication channel, a user may insert USB cable **18** into the corresponding USB interface **23** within the vehicle **31**. The user may press the test selector button **12** in order to initiate the testing of the USB communication channel as indicated in block **62**. LED **14***c* will illuminate. The technician may also operate input selector **51** at the vehicle **31** to select the USB input to CPU **3**. In one embodiment, the USB selection at the test tool **11** activates USB relay **38** and permits the playback of audio test files located on flash drive or memory stick **32** illustrated in FIG. **3**. In another embodiment, no USB controller relay is used and access to the test messages is provided immediately upon connecting USB cable **18** to USB interface **23**. In a third embodiment, the test messages are stored in persistent memory **39** at microcontroller **42**. The particular test message selected for playback is separately addressed in persistent memory **39** for playback using USB controller **43**.

To complete connectivity with CPU **3**, the service technician may have to select the USB interface **23** for input at the vehicle **31**. Upon selecting the USB output at tool **11**, and the USB input at vehicle **31**, the USB communication channel is tested as indicated at block **74**. In one embodiment, one or more test messages in one or more languages originates from memory **32** and is played back through digital-to-analog converter **9**, amplifier **11** and speaker **13** located within the vehicle, as indicated in block **80**. An English message may state, for example, "This is a test of the USB communication channel. If you can hear this message, the USB channel is working properly." If this message is heard by the technician, the USB communication channel is determined to be operational, as indicated at block **98**. If the message is not heard, there may be a problem with the USB communication channel and further diagnosis and testing may be required by the technician, as indicated at block **92**.

To test the auxiliary communication channel, a service technician may connect the auxiliary audio cable **20** to auxiliary input port **25** at the vehicle **31**. The user may then press the test selector button **12** in order to initiate the testing of the auxiliary communication channel at the tool **11**. The user may also operate an input selector button **53** located in the vehicle **31** to select the auxiliary channel input to the CPU for playback at speakers **13**. At this point, testing of the auxiliary communication channel may be tested, as illustrated in block **76**. Microprocessor **42** may retrieve an audio test file from persistent memory **39** in the selected language and output that signal through auxiliary output **20** for transmission to auxiliary input **25**, processing at CPU **3**, and playback through speakers **13**, as illustrated in block **82**. An English message may state, for example, "This is a test of the auxiliary communication channel. If you can hear this message, the auxiliary channel is working properly."

If this message is heard by the technician, the auxiliary communication channel is determined to be operational, as indicated at block **100**. If the message is not heard, there may be a problem with the auxiliary communication channel and further diagnosis and testing may be required by the technician, as indicated at block **94**.

In another embodiment of the present invention, the testing device may be configured to broadcast testing signals to all communication channels in substantially simultaneous or overlapping intervals. Alternatively, the testing device may scan through all communication channels and signal to the user automatically when to switch the protocol being tested.

The present embodiments can also be used to test multimedia communication systems or multimedia entertainment systems. Embodiments of the devices to be tested are standard entertainment or communication systems having a plurality of different communication channel inputs or a communication or entertainment system embedded within a larger apparatus assembly or computing system.

While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.

What is claimed:

1. An apparatus for remotely testing a plurality of communication channel inputs to an automobile computer, the apparatus comprising:

microprocessor electrically connected to a persistent memory having stored therein communication channel test messages corresponding to each of two or more communication channel inputs to an automobile computer, at least one of which is a wireless communication channel, wherein the microprocessor is configured to output a test message over a selected communication channel to the automobile computer;

a wireless transceiver in communication with the microprocessor for wirelessly communicating at least one of the test messages to a wireless communication input to the automobile computer; and

one or more switches connected to the microprocessor which, upon operation, cause the microprocessor to (1) pair the wireless transceiver with the wireless communication input to the automobile computer, (2) select one

of the two or more communication channel inputs and corresponding test messages for testing, and (3) output the corresponding test message over the selected communication channel input.

2. The apparatus of claim **1** wherein the wireless communication channel is a BLUETOOTH communication channel.

3. The apparatus of claim **1** additionally comprising one or more output indicators to identify which of the two or more communication channels has been selected for testing.

4. The apparatus of claim **3** wherein the output indicator is a light emitting diode.

5. The apparatus of claim **1** wherein the communication channel test messages are stored in two or more different languages, and wherein operation of the one or more switches additionally cause the microprocessor to select the language of the test message for output over the selected communication channel.

6. The apparatus of claim **1** wherein the two or more communication channels includes a universal serial bus.

7. The apparatus of claim **6** wherein a voltage differential on the universal serial bus provides power to the microprocessor.

8. The apparatus of claim **1** wherein the persistent memory is flash memory.

9. The apparatus of claim **1** additionally comprising a digital-to-analog converter for converting digitally-encoded test messages into analog audio signals.

10. A method for remotely testing the operability of two or more communication channel inputs to a vehicle computer, the method comprising:

at a test tool remote from the vehicle computer, (1) receiving input selecting one of two or more communication channel inputs to the vehicle computer, at least one of which is a wireless communication channel, (2) pairing a wireless transceiver in the test tool with a wireless transceiver electrically connected to the vehicle computer, and (3) outputting over the selected communication channel a test message unique to that communication channel.

11. The method of claim **10** additionally comprising, at the vehicle computer, (1) receiving input selecting one of one of two or more communication channel inputs to the vehicle computer, (2) receiving input for pairing a wireless transceiver in communication with the vehicle computer with a wireless transceiver in the test tool, and (3) if the test message is received at the vehicle computer over the selected communication channel, outputting the message for playback over the vehicle audio system.

12. The method of claim **10** additionally comprising illuminating at the test tool an indicator identifying which communication channel has been selected for testing.

13. The method of claim **10** additionally comprising selecting a test message language from two or more languages at the test tool, and outputting the test message over the selected communication channel in the selected language.

14. The method of claim **13** additionally comprising illuminating at the test tool an indicator identifying which test message language has been selected.

15. The method of claim **10** additionally comprising receiving at the test tool input defining a multiple digit PIN number for pairing the wireless transceiver with the wireless transceiver electrically connected to the vehicle computer.

16. The method of claim **10** wherein the wireless communication channel is a BLUETOOTH communication channel.

17. The method of claim **10** additionally comprising establishing a universal serial bus communication connection between the test tool and the vehicle computer.

18. The method of claim **10** additionally comprising establishing an analog auxiliary communication connection between the test tool and an analog input to a vehicle entertainment system.

19. The method of claim **10** additionally comprising establishing a power connection between a power supply in the vehicle and the test tool.

20. The method of claim **10** additionally comprising illuminating an indicator at the test tool to indicate the state of a pairing mode for the wireless transceiver.

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